

EDIBLE FOOD PRODUCED SUCH AS SPORTS BEVERAGES,

HEALTH DRINKS, FRUIT BARS, JAMS AND JELLIES

Specification

CROSS REFERENCE TO OTHER APPLICATIONS.

Applicant claims the benefit of the following four United States provisional patent applications:

SPORTS BEVERAGE/HEALTH DRINK, Serial No. 60/262,709
filed January 19, 2001

COMBINATION OF ALMOND FRUIT EXTRACTS OFFERING POTENTIAL
SYNERGISTIC HEALTH EFFECTS, Serial No. 60/307,623,
filed July 24, 2001

ENHANCED PRODUCTION OF INOSITOL, INOSITOL PHOSPHATES,
FLAVONOIDS, PHENOLIC ACIDS, POLYPHENOLICS, AND TERPENES,
FROM MESOCARP OF PRUNUS AMYGDALUS, Serial No. 60/307,648
filed July 24, 2001

UNIQUE DIETARY FIBER PRODUCTS FROM THE FRUIT OF SWEET
ALMOND (PRUNUS AMYGDALUS), Serial No. 60/307,622.
filed July 24, 2001

Field of the Invention

Extract from almond hulls of compounds and fiber beneficial to humans, providing sports beverages, health drinks and ingredients for fruit bars, jams and jellies, and related methods.

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Background of the Invention

The sweet almond, *prunus amygdalus*, is a stone fruit which has several unique features. It is commercially cultivated where there are long, hot, Mediterranean like summers, such as exist in Spain, Morocco, Armenia, Iran, Italy, California (U.S.A.), Australia, et al. It is unique, in that unlike others in its botanical family, such as the peach, apricot and plum, where the flesh (mesocarp) of the fruit is eaten and the seed within its shell, or stone (endocarp) is discarded, the reverse is true for the almond. Early in its maturation cycle, for a period of a few weeks, the entire fruit (seed, endocarp, and mesocarp) can be, and is, eaten, in several parts of the world. As the maturation cycle continues, the seed finally becomes the almond "nut" of commerce, and the endocarp (shell), and mesocarp are gathered aside for low value uses, such as cat litter and animal feed. The mesocarp has become dry, leathery, and astringent to the taste, reflecting the fact that the mature sweet almond mesocarp has an unusually high concentration of flavonoids compared to its botanical relatives, as well as to other fruits. This is thought to be a consequence of the length of time that the mesocarp is subject to intense heat, ultraviolet radiation, and pest infestation, as the flavonoids play protective roles against all three of these plant stress factors. The extended maturation period of the mesocarp, flowing into a remarkably stable

1 senescence period, also allows for biosynthesis of lignans in the
2 mesocarp, compared to the comparative absence of those compounds
3 in other fruits. The mesocarp, in senescence, following harvest
4 of the nut meats, remains remarkably stable in that it retains
5 its high sugars, flavonoid, and lignan content, for years, so
6 long as the mesocarps, referred to familiarly as "hulls," remain
7 in their dry harvested condition, having approximately 8% - 20%
8 water content, usually averaging about 12% free water.

9 In addition to these dry solubles, the hulls also contain
10 insoluble fiber of cellulose, hemicellulose, pectins, tannin-
11 like complex polyphenols, and ash. As dry hulls, therefore, the
12 almond mesocarp represent a potential source of useful foods,
13 food additives, pharmaceuticals, and feed additives, over and
14 above low value usage as roughage or cat litter.

15 This invention describes the creation of a beneficial sports
16 beverage that contains a unique natural mixture of sucrose,
17 invert sugars, inositol, inositol phosphates, sorbitol, vitamin
18 C, flavonoids, lignans, sodium and potassium, and smaller
19 concentrations of soluble oligosaccharides, and tannin like
20 complex polyphenols.

21 The mixture of sucrose, glucose, and fructose, and the
22 oligosaccharides in these hulls, provide a source of sugar for
23 energy metabolism, in a "metered" format, in that the sucrose and
24 glucose are readily absorbed and metabolized, followed by

1 fructose, and then the oligosaccharides. In this manner, a given
2 volume of ingested beverage, which of course is predominantly
3 water, will supply a more advantageous longer lasting input of
4 energy providing carbohydrates, than a beverage containing, for
5 example, merely glucose, or sucrose. Water replenishment is
6 essential during periods of vigorous exercise, as well as during
7 more average daily activities. However, excessive imbibition of
8 water, can lead, minimally, to feelings of bloat and nausea, and
9 potentially to the more serious life threatening effects of water
10 intoxication, or hyponatremia.

11 Inositol and sorbitol, are both polyol molecules, and are
12 also well known as "compatible osmolytes". They aid restoration
13 of homeostatic osmotic strength of plasma, and intracellular
14 fluid. In restoration of normal osmotic strength, the compatible
15 osmolytes inositol and sorbitol are uncharged molecules adding to
16 total osmolality, replacing higher concentrations of charged
17 ions, which, in excess, interfere with normal enzyme activity via
18 effects on enzyme (protein) active configurations.

19 In addition to compatible osmolyte function, the polyol
20 molecules can also contribute to "hyperhydration" activity, very
21 recently found to be a beneficial function of another polyol
22 molecule, glycerol, in vigorous exercise. Hyperhydration
23 intervention has also recently been postulated to be useful in
24 preventing syncope (dizziness, and fainting) for astronauts upon

1 return to normal gravity, after extended periods in zero gravity.

2 Inositol has further been found to be effective in promoting
3 insulin activity, and thereby, effective glucose metabolism both
4 as inositol, and as "downstream" metabolites of inositol which
5 are active in glucose transport.

6 Finally, inositol and its metabolites, play essential roles
7 in muscle recovery following sustained muscular activity, as part
8 of the manifold of events which reconstitute the actin filaments
9 of muscle structure.

10 The flavonoids in the almond hull beverage possess
11 antioxidant activity currently thought to be effective in muscle
12 recovery following strenuous exercise. Further, for very active
13 athletic activity, over long periods of time, the potential for
14 accumulated DNA damage, as well as damage to other biomolecules,
15 through oxidative attack, can represent the first step in the
16 multifactorial etiology of certain cancers which may not fully
17 develop until many years have passed. Vigorous exercise is a
18 high oxidation activity, and therefore the flavonoids in the
19 almond hull beverage aid muscle recovery, and athletic
20 performance in the immediate term, and contribute to long term
21 health status through a lifetime. The flavonoids are also now
22 well known to act as protective agents for the circulatory system
23 and heart.

24 The lignans and tannin like polyphenolics also possess

1 health protective activities, although the putative mechanisms of
2 action for the higher molecular weight tannin like molecules are
3 less well known at this time.

4 Sodium replenishment during prolonged, very vigorous
5 exercise, is now recommended. For less vigorous activities, the
6 major value of sodium in beverages is to increase palatability.
7 Potassium plays an important role in muscle recovery and
8 rehydration of intracellular fluid.

9 As the natural constituents of a fruit juice obtained from
10 mature almond mesocarps (hulls) are beneficial for health, and
11 for athletic performance, this juice should be obtained with as
12 little loss of constituents as possible, compatible with maximal
13 economic recovery of juice.

14 The above and other features of this invention will be fully
15 understood from the following detailed description and the
16 accompanying drawings in which:

17 Brief Description of the Drawings

18 The single figure is a process diagram showing the preferred
19 features of the invention.

20 Detailed Description of the Invention

21 Dry almond hulls, typically in the range of 6% - 15% free
22 water content, are initially ground to a particles in the range
23 of 10 - 40 mesh (ASTM), using well known comminution equipment,
24 such as the Fitzpatrick mill. This reduction in size is to

1 enable more efficient hot water extraction of the more complex,
2 higher molecular weight polyphenolics, which are cell-structure
3 bound, rather than free in solution in cell vacuoles.

4 It is well known that many fruit juices are produced by
5 variations of press procedures on the fruits which are naturally
6 composed of 50%-90% moisture containing the juice molecules of
7 interest. Extraction efficiency of juices from such fruits,
8 using press procedures, is in the range of 55%-75%. Continuous
9 counter current juice extraction from the same fruits can
10 increase extraction efficiency to 80%-98%.

11 The almond fruit (hull) is harvested at approximately 5%-20%
12 moisture content, typically about 10%-12% moisture. The hull,
13 depending upon varietal, geographic, and seasonal variations, can
14 have upwards of 50%-60% water solubles content. At 10% incoming
15 as is total moisture content, the hull solubles cannot be
16 extracted by press procedures or by continuous counter current
17 procedures. The hulls must first undergo a water imbibition
18 step, to raise the moisture content into the range of 50%-80%.
19 At this moisture content, the intact hulls can be subjected to
20 counter current extraction for economical extraction efficiency.

21 Examples: 1. Using intact hulls (typically dimensions
22 approximately 1 1/2 inch x 3/4 inch x 1/8 inch) in pilot scale
23 simulated Roberts Battery counter current extraction, following
24 preliminary water rehydration step, adding water to hulls in the

1 weight ratio of approximately 2.5:1, and with water temperature
2 at 55 degrees C+/-2 degrees C, solubles extraction reaches
3 93%+/-2% efficiency.

4 2. Using hulls which have been reduced in size to 1/16
5 - 1/8 inch largest diameter, and other variables identical to
6 example 1, the extraction efficiency is increased 98% +/- 1%.

7 The increase in extracted solubles in example 2 vs. example
8 1 is due to increased extraction of larger molecular weight, more
9 difficulty water soluble, flavonoids, anthocyanidins, polymerized
10 polyphenolics, lignans, lignins, and trace amounts of additional
11 hexoses and pentoses from slight cellulosic and hemicellulosic
12 hydrolysis.

13 The "Roberts Battery" is one of the earliest process
14 versions of counter current equipment used in both water solubles
15 and oils extraction, still useful in this invention. There are
16 now several commercial continuous counter current extractors in
17 use worldwide, and the choice of a process unit will depend upon
18 the usual features of capital cost, operational cost, efficiency,
19 size, etc.

20 The rehydrated particles are then extracted with hot water
21 in counter current (CC) fashion, with counter current extractor
22 equipment well known to processors of cane and beet sugar, soy
23 oil, et al. The hot water will be kept in the range of 35 degree
24 celsius - 70 degree celsius, preferably 50 degree +/- 5 degree in

1 order to minimize degradation of the flavonoid molecules. This
2 temperature range will also inhibit possible bacterial and fungal
3 growth contamination during the counter current extraction
4 period.

5 The extract juice is separated from the undissolved solids,
6 using conventional equipment such as vacuum rotary drum
7 equipment, or centrifugation.

8 The juice, now separated from most of the suspended solids,
9 will be subject to stages of ultrafiltration (UF), starting with
10 UF of approximately 100,000 - 300,000 NMCO (Nominal Molecular
11 Weight Cut Off), and finishing with UF using 5,000 - 10,000 NMCO.
12 This will yield a juice with characteristic straw to golden
13 color, sweet fruity taste, and "cold sterilized", to be suitably
14 free of microbiological contamination.

15 The final juice can have a Brix concentration, whose value
16 reflects the fact that yearly variations occur in solubles
17 content of the several almond varieties that are grown, and are
18 harvested together. Therefore, for purposes of optimal sports
19 beverage benefit, the osmolality of the beverage will be adjusted
20 with addition of pure sterile water, to produce a beverage which
21 has an osmolality close to that of human plasma.

22 For purposes of wide distribution of the beverage, the CC
23 juice, following UF processing, may be concentrated to a juice
24 "molasses", of 60 degrees Brix - 80 degrees Brix, using several

1 stage vacuum evaporation at a temperature not to exceed 70 degree
2 celsius, to minimize degradation of flavonoids. The molasses can
3 now be more economically transported to other locations, and then
4 diluted and packaged for distribution from those locations.

5 The concentrated juice can also be presented as an elixir
6 supplement. The sports drink, in the range of 8 to 15 degree
7 Brix concentration, is designed so that up to about a liter or so
8 per exercise duration can be consumed for water, energy, and
9 other beneficial components replenishment. A concentrated
10 elixir, in the range of 45 to 80 degree Brix, will be designed
11 for recommended daily consumption of tablespoon quantities. A
12 further presentation of the concentrated juice will be one in
13 which the concentrate in the range of 50 to 80 degree Brix, is
14 combined with the processed hull solids, to produce a solid
15 composition bar.

16 This concentrate can also be used as a constituent of jams
17 and jellies, and for confectionery uses.

18 The almond fruit juice, which after ultrafiltration through
19 10,000 NMCO membrane, can be concentrated to near 80 degrees.
20 Brix pourable syrup, is an excellent fruit syrup, at much lower
21 degree Brix concentrations for preparation of fruit bars, and as
22 an immediate step preparation of fruit jam.

23 (1) almond fruit jam, almond fruit juice concentrate at
24 approximately 50 degrees Brix concentrate, pH=4.8 +/- 0.2, is

1 acidified by addition of citric, tartaric, malic, and fumaric
2 acids to pH=4.1. Acidified syrup further concentrated to
3 approximately 62 degrees Brix, at near boiling temperature and
4 atmospheric pressure. A solution of 4 degrees apple pectin in
5 20% sucrose was added to the concentrate, along with additional
6 citric acid to lower pH further to 3.3 +/- 0.2, and the mixture
7 stirred and further evaporated to final 75 degrees +/- 1 degree
8 Brix. The mixture then poured into aluminum muffin pans for
9 setting to a jam upon cooling.

10 (2) almond fruit jam prepared with almond fruit pectin. The
11 almond fruit contains pectin in the cellulosic fiber residue
12 collected after juice extraction from the fruit. One pectin
13 fraction recovered from the residue was recovered through a
14 dilute sodium carbonate wash of the fiber, followed by
15 "precipitation" of the pectin with isopropyl alcohol treated
16 suspension. The pectin film was recovered and dried to a powder.
17 This pectin fraction, due to the alkaline wash procedure, is a
18 low methoxy pectin, requiring addition of Ca^{++} to form a gel with
19 a fruit syrup. The almond fruit juice concentrate used in
20 example 1, above (PH=4.8, 50 degrees Brix) was not further
21 acidified, nor further concentrated. A solution of 4 grams of
22 almond fruit pectin in 100 ml of 20% sucrose was added to the
23 syrup, followed by 1.3 grams of $\text{Ca}(\text{H}_2\text{PO}_4)_2 + \text{H}_2\text{O}$ (monobasic
24 calcium phosphate). The mixture was stirred, and evaporated back

1 to approximately 52 degrees Brix concentration, and then poured
2 into an aluminum muffin pan for setting to a gel upon cooling.

3 (3) almond fruit bar 30 ml of a syrup concentrate, pH=4.8
4 containing 0.5g of almond fruit low methoxy pectin, plus 150 mg
5 of monobasic calcium phosphate was heated to near boiling, and
6 then 10g +/- 2g of finely ground (approximately 150 mesh ASTM)
7 dry almond fruit fiber added to the solution, with stirring and
8 then transferred to an aluminum muffin pan for continued heating
9 at 350 degrees F for 10 minutes and then allowed to cool to a
10 solid bar consistency.

11 Phytic acid and inositol, both present in the almond hull
12 extract, acting together, have been shown to inhibit certain
13 cancers in experimental animal models, and both phytic acid, and
14 inositol, have also been shown to have lipid and cholesterol
15 lowering effects, thereby promoting healthier vascular and heart
16 function. One type of sports/health beverage to be produced will
17 therefore contain both of these
18 molecules.

19 Another beverage type to be produced will maximize the
20 hyperhydration and compatible osmolyte actives of the beverage.
21 This will be accomplished by the addition of a phytase enzyme
22 just after the CC step as shown at 20 in Fig. 1.

23 This will break down the considerable phytic acid content of
24 the mesocarp, yielding additional inositol concentration,

1 additional free sodium, magnesium, calcium and potassium ions,
2 and inositol phosphates. The breakdown of phytic acid also
3 prevents the binding of these beneficial elements in the
4 intestinal tract and plasma of the consumers of the beverage.
5 Phytic acid is well known to be a chelator of cations, especially
6 of the transition elements calcium and magnesium.

7 Yeasts and fungi which can be used, in batch or fed batch
8 fermentation, of almond fruit juice containing phytic acid, in
9 order to generate inositol phosphates, containing one to five
10 phosphates, and myo-inositol, included, but are not limited to
11 *Saccharomyces cerevisiae*, *Saccharomyces pombe*, *Aspergillus*
12 *ficuum*, *Aspergillus flavis*. *Aspergillus niger*, *Hansenula anomala*,
13 *Kluyveromyces fragilis*, *Schwanniomyces castelli*, *Torulopsis*
14 *candida*. For use of the intact, viable yeast or fungus, a batch
15 fermentation is run for varying periods of time, typically 5 to
16 40 hours to generate mixtures of inositol phosphates. To
17 completely hydrolyze phytic acid to myo-inositol and inorganic
18 phosphate, the fermentation is preferably run fed batch mode 24 -
19 48 hours.

20 It is also possible to use pure heat stable phytase enzymes,
21 extracted from yeasts and fungi in a reactor vessel, rather than
22 fermentation mode in order to hydrolyze phytic acid to myo-
23 inositol and inorganic phosphate. There are several such enzymes
24 available, such as the phytase extracted from *Aspergillus*

1 fumigatus (L. Pasamontes, M. Haiker, M. Wyss, M. Tessier,
2 A.P.G.M. van Loon, Appl. Environ. Microbiology 63(5),1696-1700,
3 1997). Using such enzymes in a reactor vessel at temperatures
4 between 50 degrees C and 80 degrees C, usually preferably 65
5 degrees C+/-3 degrees C, mixtures of inositol phosphates can be
6 generated in less than 10 hours, and myo-inositol can be produced
7 in less than 24 hours.

8 A suitable and exemplary finished beverage will have an
9 approximate characteristic analytic profile as follows:

10 8 - 15 degree Brix dissolved solids

11 280 - 400 mOsm/L osmolality

12 sugars: sucrose 0.4%

13 glucose 2.5%

14 fructose 2.9%

15 inositol 0.6%

16 sorbitol 0.6%

17 oligosaccharides <0.1%

18 sodium 5 meq/L

19 potassium 90 meq/L

20 polyphenolics (flavonoids, lignans,
21 tannin like molecules) 0.1%

22 protein <0.02%

23 lipid <0.05%

24 Dry almond hulls in their normal condition contain the

1 various products of interest herein, in a complicated physical
2 structure. Having been dried for a substantial period of time,
3 the moisture is quite low, which has led to stability of the
4 various components. However, inherently the hulls contain
5 substantial amounts of yeasts, fungi and bacteria, in quiescent
6 forms. . These microbes, while quiescent, have no affect on the
7 other compositions. But when wet and at suitable temperatures,
8 they will promptly become active degrade them and reduce the
9 concentration of the desired products. It thereby results that
10 maintenance of suitable moisture and temperature after wetting
11 the hulls is requisite for optimum recovery of the desired
12 products.

13 When considering the physical structure that encloses the
14 components, it should be remembered that the hulls are what
15 remains of a mesocarp (i.e. fruit) structure, having many unique
16 properties of its own. For example, at least when wet it is a
17 semipermeable structure that ordinarily prevents the passage
18 through it of high molecular weight compounds. For this reason
19 it has previously been suggested to manipulate this structure to
20 utilize this feature.

21 While this previous concept permits extraction of low
22 molecular weight, highly water soluble compounds like sugars, it
23 prevents the effective extraction of larger molecular weight
24 components and less water-soluble components, which are of great

1 importance to the product obtained with this invention. The
2 severe maceration of the hull particles substantially destroys
3 the function of the membranes, and makes available recovery of
4 these other components.

5 This still does not settle the matter, because both the very
6 soluble and the less soluble compounds must yet be extracted.
7 Counter-current (CC) extraction makes this possible because it
8 takes advantage of the solubility products of both types of
9 compounds.

10 Again, this separation takes time as does the reconditioning
11 of the macerated particles to thoroughly rehydrate them. The
12 consequence of time is the opportunity for yeasts and other
13 microbes to grow at the expense of the sugars. The sugars, of
14 course, are a primary objective of this invention. Left at room
15 temperature, time spent in processing can result in serious
16 degradation of the products, even producing alcohol.

17 In this invention the process before ultrafiltration to
18 remove the yeast is maintained at temperatures adverse to yeast
19 proliferation. Generally between about 40 degrees C and about 70
20 degrees C, preferably around 55 degrees C will be used. Thus,
21 the natural tendency for the principal degradation of the
22 production of the desired compounds is prevented.

23
24

1 This invention is not limited by the embodiments shown in
2 the drawings and described in the description, which are given by
3 way of example and not of limitation, but only in accordance with
4 the scope of the appended claims.